read, in Berlin Hillebrand announced that the mineral is a mercury-ammonium compound; it is a mixture of mercury ammonium chloride with some sulphate or oxysulphate. Some interesting photographs illustrate the optical heterogeneity of the mineral. Kleinite is hexagonal in symmetry, but basal sections are only singly refracting when heated above 130°; after cooling very slowly, in process of years, again become biaxial.

Three of these bulletins (Nos. 397, 408, and 414) state the results of inspections of western mineral fields where mining was once more active than it is now. Mr. F. C. Schrader describes the ore deposits of Mohave County, in north-western Arizona. The country consists of a plateau of pre-Cambrian gneisses covered in places by Cainozoic volcanic rocks, and flanked by Palæozoic sediments in the valley of the Colorado River. The climate is warm, and with a 5-inch rainfall and high evaporation there is little surface water, and the rocks are oxidised to the depth of usually from 200 to 600 feet. The mines are numerous, but they are all hampered by the difficulties of access and high costs, and so none have been worked very deeply. The outcrops were removed thirty years ago. The mines belong to two main types, one represented in the Cerbat Range, occurring in the pre-Cambrian rocks, and the other, as in the Black Mountain, found in the Cainozoic volcanic formation. The ores in the latter are found only in association with chloritic andesites. The field shows many points of interest, and the results will be watched with interest as the mines go deeper. The plans suggest that some of the ore shoots have been formed from ascending solutions. The evidence available is insufficient to throw much light on general problems, but Mr. Schrader's report will be indispensable in the future development of the field.

Mr. W. H. Emmons's reconnaissance on some mining camps in Nevada also deals with small scattered mines of which most of the direct evidence has been lost. Some of them were worked fifty years ago, and mining was most active during the silver boom of the 'eighties. The mines, unlike those in Mohave County, yield a large variety of minerals. The area consists of Palæozoic sediments, ranging from the Cambrian to the Carboniferous, which have been invaded by Cretaceous granodiorites, and covered in places by Miocene rhyolites, andesites, and basalts. One series of mines consists of replacements in what the author calls the "marbleised limestone" around the Cretaceous granodiorites, and a second series occurs with the Cainozoic eruptives, but only in association with the andesites; the basalts are always barren, and the rhyolites are only productive when near andesite. The chief metals in both series of mines are gold and silver. The gold is relatively more abundant in the older lodes, where it is associated with copper and lead. The mines only occur where the rocks have been leached by hot water, and thus prospectors recognise promising positions by the colour of the weathered rocks.

Mr. F. L. Ransome has examined Humboldt County, Nevada, of which the map prepared by the historic Survey of the Fortieth Parallel is still the best. Mining began in the district about 1860 on ores of antimonial silver with stibnite and cinnabar. In Copperwood Canyon small veins of nickel and cobalt ores occur in an altered andesite beside a diorite, probably of Cretaceous age. Mr. Ransome shows his characteristic insight in the classification of the ore bodies and in such illuminating diagrammatic sections as that of the Sheba mine (p. 42).

The gypsum deposits of California are described in a short memoir by Mr. F. L. Hess. The gypsum is mined for use as plaster and a fertiliser. Some of it occurs in "gypsite," a material containing grains of gypsum too small to be readily discernible to the eye. It is there an efflorescent product, due to the evaporation of water, which has percolated through underlying gypsiferous beds. Some massive deposits formed by the evaporation of shallow lakes and by precipitation in shallow sea water are also of local commercial value. The veins of gypsum, including both selenite and satinspar, have no intrinsic value, but are worked as the cheapest method of holding mineral leases on land which may yield oil. Sufficient work is done on the gypsum to maintain the lease without the expense of boring for oil, and thus dodging the law by using one mineral to maintain an unfair claim to another.

The valuation of coal lands is a problem which has long taxed the ingenuity of experts on mining law. In Bulletin 424 Mr. Fisher contributes to the discussion a summary of the depth and minimum thickness of coal seams worked in various countries. The deepest coal mining recorded is from 3937 feet, in Belgium; the deepest in Britain is at 3483 feet, in Rams Mine, Pendelton; and depths of more than 3000 feet have been reached in France and Germany. Forty years ago a British Coal Commission recognised that mining would reach a depth of 4000 feet, but such is the wealth in fuel of the United States that coal below 3000 feet is still disregarded in valuation. The United States, moreover, has not yet been driven to work such thin coals as are wrought in England and Belgium. The thinnest English seams worked at present independently are a cannel coal of 8 inches and ordinary coal 10 inches thick. Seams 12 inches thick are worked in Belgium and Scotland, where beds of less than 2 feet thick are worked extensively.

The red iron ores in the Silurian rocks of Alabama, described in Bulletin 400, are second in importance in the United States only to those of the Lake Superior district. They are low-grade ores, but being near fluxes and fuel are cheaply worked. The Clinton ores have generally been regarded as a residual deposit due to concentration of iron oxide by solution of a ferruginous limestone. This view has been based upon the belief, due to Porter and I. C. Russell, that the ironstones pass below into normal limestone. This view has been accepted by many later economic geologists, but is rejected by Eckel, as the ore is already being mined far from the outcrop, and has been found in New York in bores ten to fifteen miles from the outcrop, and nearly 1000 feet below the surface. The ore is often oolitic and contains many marine fossils which have been altered into iron oxide, but that this change happened during the deposition of the rock is indicated by several facts. Thus many of the oolitic grains contain a nucleus of quartz grains surrounded by concentric layers of iron ore, which is covered by carbonate of lime. A fuller account and figures of the microscopic structure of the ores would have been useful. As the oolitic grains have been cemented by iron oxide, some replacement appears to have taken place after the formation of the bed. Mr. Eckel, however, produces weighty evidence in support of his view that the ore is mainly of contemporary origin, though recent work shows that other American geologists reject this explanation, and regard the estimates based on it as exaggerated.

The brown ores of Alabama are admitted by Mr. Eckel to be epigenetic; they are interbedded with Cambro-Ordovician, Cretaceous, and Cainozoic rocks, but are all of Cainozoic formation.

Mr. Maddren's report on some Yukon placer deposits shows that the gold has been derived from lodes formed by the intrusions of acid rocks in Mesozoic or Lower Cainozoic times. The gold is usually coarse, but its concentration has been slow, because the cold acts as a cementing agent, and the erosion of the frozen ground is very slow. The report gives some interesting information as to the relative extent of Glacial and post-Glacial denudation in some Alaskan valleys.

J. W. G.

ON THE SENSIBILITY OF THE EYE TO VARIATIONS OF WAVE-LENGTH IN THE YELLOW REGION OF THE SPECTRUM.[1]

DR. EDRIDGE-GREEN[2] has introduced a method of classifying colour-vision by determining the number of separate parts or divisions in the spectrum within each of which the observer can perceive no colour difference. Movable screens are provided in the focal plane of the spectroscopic telescope, by which the part admitted to the eye is limited and the limits measured in terms of wave-length. Beginning at the extreme visible red, more and more of the spectrum is admitted until a change of colour (not merely of brightness) is just perceptible. This gives the first division. The second division starts from the place just determined, and is limited in the direction of

[1] Abstract of a paper read before the Royal Society on December 8, 1910, by Lord Rayleigh, O.M., F.R.S.

[2] Roy. Soc. Proc., B, 1910, vol. lxxxii., p. 458, and earlier writings.

shorter wave-length by the same condition. In this way the whole spectrum is divided into a number of contiguous divisions, or patches, which Dr. Green terms monochromatic.

"Tested with this instrument a normal individual will, as a rule, name six distinct colours (viz. red, orange, yellow, green, blue, violet), and will mark out by means of the shutters about 18 monochromatic patches. Occasionally we come across individuals with a greater power of differentiating hues, to whom, as to Newton, there is a distinct colour between the blue and violet, which Newton called indigo. Such individuals will mark out a greater number of monochromatic patches, from 22 up to 29. The limited number of monochromatic patches which can be marked out in this way is at first surprising when we consider how insensibly one part of the spectrum seems to shade into the next when the whole of the spectrum is looked at. The number and position of the patches present, however, great uniformity from one case to another."

Being curious to know into what class my own vision would fall on this system, I was glad to be tested by Dr. Green last July. The number of patches proved to be 17, a little short of what Dr. Green lays down in the passage above quoted as normal. The limits of the actual patches were as follows:—

780—635½—624—612—603—595—586—576—560—541—521—509—500—489½—477—462—443—426.

Thus in the region of the D lines a patch including wave-lengths between 595 and 586 did not manifest a difference of colour. The interval between the D lines on the above scale being 0·60, it appears that my "monochromatic patch" was 15 times this interval.

While it is undoubtedly true that in this way of working no colour-difference was perceptible as the eye travelled backwards and forwards over the patch, my experience with colour discs and other colour-mixing arrangements made me feel certain that under more favourable conditions I could discriminate much smaller differences of wave-length. Special experiments have since proved that I can, in fact, discriminate by colour between points in the spectrum so close together as the two D lines.

In order to compare two colours with advantage it is necessary that each should extend with uniformity over a considerable angular area, and that the two areas should be in close juxtaposition. The requirements of the case are sufficiently met by a colour-box (after Maxwell) such as I described nearly thirty years ago.[1] In this form of apparatus a second slit, placed at the focus, allows a narrow width of the spectrum to pass; but instead of regarding the transmitted portion with an eye-piece, the eye is brought close to the slit and focussed upon the prism, which thus appears uniformly lighted with such rays as the second slit allows to pass. The light thus presented is, of course, not absolutely homogeneous; it includes a mixture of neighbouring spectrum rays, the degree of purity augmenting as the slits are narrowed. With the aid of a refracting prism of small angle (set perpendicularly to the dispersing prisms) the field of view is divided into two parts, which correspond to any desired colours according to the situation of the two primary slits. For the present purpose these primary slits lie nearly in one straight line, inasmuch as the two spectrum colours to be compared are close together.

In making the observations on sensitiveness, one primary slit, as well as the eye-slit, remains fixed, the position being chosen so as to provide yellow light from the neighbourhood of D. The second slit can be moved as a whole while retaining its width.

The procedure is quite simple. If the colours seen are strongly contrasted, the movable slit is displaced until the difference is moderate. Marks may then be given: O, denoting that the difference is uncertain; R_1, that it is just distinct in the direction of making the second patch the redder; G_1, that it is just distinct in the opposite direction. Similarly, R_2, G_2, denote differences in the two directions which are more than distinct, and so on. After each observation worth recording, the position of the movable slit is measured.

[1] NATURE, 1881, vol. xxv., pp. 64–66; "Scientific Papers," vol. i., p. 543. See also NATURE, August 18, 1910.

In this manner, as the result of sets of observations made on several days, it was found that a movement of the second slit through 0·15 mm. was sufficient to carry the variable colour from being distinctly redder than the standard to distinctly greener. We may conclude that the eye is capable of appreciating without fail a difference of situation represented by 0·07 mm.

It remains to interpret the result in terms of wave-lengths. By allowing light to enter at the eye-slit, or rather at a narrower slit superposed upon it, a spectrum is formed at the other end the scale of which has to be determined. It appeared that the distance from D to E was 7 mm. The difference of wave-length between these lines is 62·3. The perceptible difference is 1/100 of this, corresponding nearly enough to the difference between the D lines. I think I am safe in saying that I could distinguish the colours of the two D lines if favourably presented to the eye.

This degree of sensitiveness, though not higher than I had expected, is a little difficult to reconcile with the monochromatic appearance of a portion of the spectrum fifteen times wider. I suppose that the gradual character of the transition is an obstacle to the recognition of differences. The question of angular magnitude may also enter. No doubt a very small apparent magnitude would be unfavourable. It is possible that in Dr. Green's apparatus an eye-piece of higher power, with a corresponding augmentation in the intrinsic brilliancy of the source of light, would allow of an increase in the number of distinguishable patches. The experiment would be worth a trial.

It will be seen that the existence of "monochromatic patches" in the spectrum is far from meaning that the eye is incapable of making chromatic distinctions within their range. I do not infer from this that the results of the method are without significance. Undoubtedly it is possible by means of it to classify colour-vision, and such a classification cannot be without interest, even if we fail as yet to understand exactly what it means.

THE PROGRESSIVE DISCLOSURE OF THE ENTIRE ATMOSPHERE OF THE SUN.[1]

LE soleil auquel est consacrée cette conférence est un magnifique sujet d'études. Tous les hommes sentent plus ou moins clairement que les destinées terrestres sont liées étroitement à celles du soleil, et qu'il est nécessaire de reconnaître sa nature intime, son rayonnement total, ses variations, en un mot son action précise et complète sur notre globe. Notre dépendance vis-à-vis du soleil est absolue, et récemment, elle a été résumée d'une manière simple par un homme politique français, maintenant ministre des finances, auquel je demandais un crédit spécial pour l'observatoire de Meudon que je dirige, et pour les recherches solaires. Il refusait d'abord, en alléguant l'acroissement continu des dépenses publiques. Puis, comme j'insistais, il s'écria: "Vous avez raison, le soleil est *notre maître* à tous; il est impossible que nous ne fassions pas quelque chose." C'est ainsi que l'observatoire de Meudon a pu joindre à son budget ordinaire une somme supplémentaire, certes peu élevée, mais qui est arrivée au moment opportun, et nous a beaucoup aidés dans les recherches que je vous présente aujourd'hui.

L'étude moderne du soleil exige en effet des installations coûteuses, des appareils compliqués et un personnel spécial apte aussi bien aux observations physiques qu'aux observations astronomiques. Or le soleil luit pour tout le monde, et mûrit toutes les moissons; et, à priori, il semble naturel que tous les hommes de la planète apportent leur concours aux recherches solaires. Partant de cette idée, j'ai proposé, il y a quelques années, à la Société astronomique de France une taxe spéciale et générale pour le soleil—et d'ailleurs très minime. Si chaque français, ai-je remarqué, donnait par an un sou, un simple sou pour le soleil, la somme totale serait encore élevée; elle permettrait d'assurer l'enregistrement continu du soleil et de ses variations, non encore réalisé, et donc une connaissance plus approfondie de l'astre. Mais les taxes nouvelles sont toujours plus nombreuses, et celle-là, bien que très faible et très légitime,

[1] Discourse delivered at the Royal Institution of Great Britain on Friday June 10, 1910, by Dr. H. Deslandres, Membre de l'Institut